TECHNOLOGY ACCEPTANCE: A FUSION OF HUMAN-COMPUTER INTERACTION AND MANAGEMENT INFORMATION SYSTEMS CONSTRUCTS

THESIS

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THESIS

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Patrick W. Wright

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Abstract

In recent years, information technology has advanced at a pace that few would have anticipated. It has been estimated that the computing power of the modern desktop computer has been increasing at the rate of 1000% per decade. In combination with the development of personal computers, the advent of networks and the world wide web provide unprecedented access to information and computing power. However, the problem of developing useful user interfaces remains a problem. In many military and commercial settings, the increased computing power offered by current information technology remains unexploited because of user interfaces that are difficult to use.

This thesis reports on the examination of constructs related to user acceptance of information systems from two disciplines, human-computer interaction (HCI) and management information systems (MIS). More specifically, research was conducted to evaluate the possibility of overlap between the two divergent fields. The Technology Acceptance Model (TAM) from MIS research was examined in light of the HCI constructs of efficiency, effectiveness, and satisfaction. Of interest was the impact of efficiency, effectiveness, and satisfaction on the formulation of user perceptions of ease of use.

The empirical data suggests that satisfaction plays a major role in the formulation of user perceptions ($p<0.01$), while the role of efficiency and effectiveness are minimal.

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I. Introduction

Background

Acceptance of technology by users has been studied for more than a decade. The attempt to capture and define the characteristics of technology that promote acceptance, or define a model that can be used to successfully predict acceptance of technology has been at the heart of this research (Fishbein and Ajzen, 1975; Davis, 1989; Venkatesh and Davis, 1996). In general, user acceptance has been "defined as the demonstrable willingness within a user group to employ information technology for tasks it is designed to support" (Dillon & Morris, 1996).

Interest in user acceptance is widespread, finding appeal at many levels of the information technology (IT) industry and throughout the business community. Business enterprises have a natural interest because they must make sizable investments in IT as a means of obtaining competitive advantage through reduction of costs, or reduction of processing or production time. The current trend in business is for greater and greater reliance on IT to improve effectiveness and efficiency, and ultimately, the bottom line. From the perspective of business enterprises that utilize IT, such investments should procure new capabilities or improvements in existing capabilities considered necessary for business competition. However, the consequential benefits of such investments are not guaranteed. For various reasons, IT does not always provide the desired advantages

or improvements; in fact, an ill-conceived IT program can have negative effects on an organization (Landauer, 1995).

There are many causes for ineffectual IT investment and employment, such as unrealistic expectations of IT, poorly matched hardware and software, insufficient investment of time and/or money, and inadequate training. The lack of user acceptance that may accompany any of these unsatisfactory conditions can be the death knell of a system. No matter how capable a system is, if users reject the system, the capability is not exploited and the benefit of the investment is not experienced (Davis, Bagozzi, and Warshaw, 1989). High costs are associated with the innovative use of IT, and investment in systems that are not accepted by the intended users must be avoided. Innovative IT applications can be expensive, but even the use of standard systems employing conventional configurations and software can impose a significant financial burden on a small or medium sized enterprise. Indeed, avoidance of the negative consequences of inadequate IT implementations motivates much of the interest in technology acceptance.

In addition to the need for user acceptance in the business arena, investigation into user acceptance is also motivated by competition within the IT industry. Within the technology industry competition remains fierce, further motivating the necessity to develop systems that are readily received. User acceptance of software products can mean success or failure for software firms. Often the distinguishing characteristic between competing products, especially in consumer electronics and software, is the ease of use of the products. As a result ease of use is of critical and increasing importance.

According to March (1994:11), user-centered design is expanding traditional design by encompassing cognitive and emotional aspects of user response:

> Many companies will also have to rethink and reorganize the design process…to ensure that usability is designed into the product from the outset. With the gap between competing products narrowing in terms of performance and quality, the experience that a product delivers is rapidly becoming the key to offering distinctive value to the customer.

In the national defense arena usability is also taking on increased importance. The unique needs of the military have led to the development of an acquisition industry that produces specialized equipment for military applications. In this setting, it is critical that users accept and use provided equipment for its intended purpose.

Management Information Systems (MIS) Perspective

From a theoretical perspective, the Technology Acceptance Model (Davis, Bagozzi, and Warshaw 1989) represents an attempt to integrate external variables, user attitudes and perceptions, and system features into a model that can be used by practitioners and researchers to explain and predict actual system usage (see Figure 1). The Technology Acceptance Model (TAM) has subsequently been supported by a large body of research results and has become the most widely accepted model of acceptance in the IT arena (e.g., see Adams, Nelson, and Todd, 1992, Dillon and Morris, 1996; and Venkatesh and Davis, 1996). Briefly, TAM posits that external factors impact the user's internal beliefs and attitudes towards technology, and beliefs and attitudes influence the user's intention to use or reject the subject system.

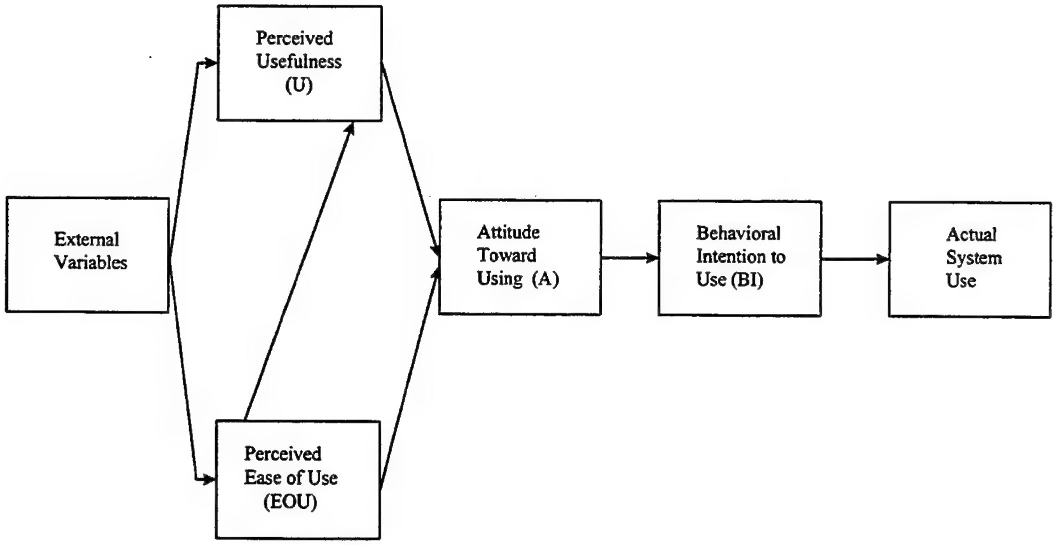


Figure 1. The Technology Acceptance Model

Perceived Ease of Use (EOU) is a construct in the TAM that refers to the user's belief that use of the target system will be free of effort (Davis, Bagozzi, and Warshaw 1989:985). Behavioral Intent (BI) refers to the strength of the intention to perform a specified action, in this case, use the system. The current state of understanding on the relationship between EOU and BI indicates that a strong positive correlation exists between EOU and BI. That is, the easier a system is to use, the more likely actual use will occur. However, less is known about the antecedents of EOU. What is known is that EOU is affected by a variety of factors, both external and internal. External factors are associated with the environment, and internal factors are within the user. More specifically, the external factors include such items as computer interface, training, and documentation. Internal factors include computer self-efficacy, enjoyment, and anxiety.

Figure 1 depicts the relationship between external variables and EOU. A partial list of external variables was provided in the preceding paragraph. All of these factors

contribute differently to forming EOU. It is also likely that other non-specified external factors affect the formulation of EOU, but the current state of knowledge does not define all possible factors.

Human Computer Interaction (HCI) Perspective

It is important to note that contributions in defining the factors that contribute to EOU have been made by both Management Information Systems (MIS) and Human Computer Interaction (HCI) researchers. In particular, HCI efforts have done much to identify and develop quantifiable measures of external variables (Shneiderman, 1992:2-19). Although the HCI research has historically focused on the definition and measurement of usability, while subject MIS research has focused on user perceptions, it may be possible to define theoretical ground common to both the MIS and HCI views of user acceptance. It is also possible that the separate pursuits for understanding in the area of user acceptance have led MIS and HCI researchers to common ground, and that the divergent terminology and perspective of the two disciplines have obscured the commonality. In TAM, acceptance is operationally defined by actual system usage. In turn, acceptance is determined by a wide range of attitudes, perceptions, and external variables. It is reasonable to conclude that external variables such as effectiveness and efficiency play an important role in forming perceptions of EOU. Effectiveness and efficiency are actually determinants borrowed from the HCI definition of usability. Within the HCI perspective, effectiveness and efficiency are usability variables that can be operationally defined and measured to produce a quantifiable definition of usability (Dillon and Morris, 1996:20). It may be postulated that subjective usability mediates

between objective usability and use in the same manner that EOU mediates between external variables and actual use.

It is possible that EOU perceptions are formed through an experience-based cognitive evaluation of the target system. This does not imply that a user devises a formal measure of efficiency and effectiveness, rather that the user formulates critical qualitative measures of efficiency and effectiveness as by-products of objective experience with the target system. It is also possible that satisfaction, an additional component of the HCI usability construct, contributes to perceived EOU. It may be postulated that the EOU perceptions are indeed formed by a cognitive evaluation of the target system. Specifically, it may be possible that EOU perceptions are shaped through the external determinants that are summed in efficiency and effectiveness measures.

Research Question

At a theoretical level this research deals with the question of predicting user acceptance. The usability constructs of efficiency, effectiveness, and satisfaction largely measure the ability of system users to complete tasks. System design features affect system usefulness and also lead to EOU perceptions (Davis, Bagozzi, and Warshaw, 1989). But there remains a more fundamental issue: Will users voluntarily use a system to accomplish tasks? In particular, this study focuses on the role of objective usability in forming EOU perceptions.

The problem dealt with in this research can be summarized as follows: Can it be shown that the MIS concepts of external variable, EOU, and actual use correspond with the HCI concepts of objective usability, subjective usability, and actual use?

This thesis reports on an empirical study conducted to verify a correspondence between the concepts of external variables and objective usability; and EOU and subjective usability. During and subsequent to a word processing task, two groups were measured according to constructs that rise from the concepts of usability, satisfaction, and perceptions about use. A review of the relevant literature will be followed by a detailed presentation of the methodology used in this research. This will be followed by a presentation of the statistical analysis and a discussion of the results.

II. Literature Review

Introduction

The intention of this review is to collect and examine the relevant knowledge and research stream related to formulation of user perceptions and usability issues. Computer processing power continues to increase at a rapid rate. In fact, computing power has historically increased at about 1000% per decade (Davis, Bagozzi, and Warshaw, 1989:982). This continuous improvement in computing makes possible the expanding role of the computer at work and at home. Modern manufacturing and services have been redesigned to capitalize on the control and data analysis capabilities of the computer. As an example of the move to greater commercial reliance on computers, McDonald's Restaurants is currently transitioning to ARCH (Automated Restaurant Crew Helper), a computer-based system that will automate food preparation, inventory control, transaction processes, and even predict future demands. The system will sharply reduce manpower requirements and improve efficiency of service operations (Murray, 1993). The traditional use of computerized systems in manufacturing is now being complemented by the development of computerized systems for use in service industries. Expansion of computer use in the service industries portends an even greater role for computers in the future.

The trend toward greater and more widespread computer utilization may create the impression that user acceptance is a mature science, when, in fact, information system (IS) researchers and designers are still seeking knowledge and methods that will lead to the ability to predict user acceptance, e.g., Davis, Bagozzi, and Warshaw, 1989;

Venkatesh and Davis, 1996. User acceptance has been defined as "the demonstrable willingness within a user group to employ IT for the tasks it is designed to support" (Dillon and Morris, 1996:4). Understanding the perceptions and motivations that precede acceptance or rejection of a system has long been problematic for IS professionals (Swanson, 1988).

Researchers have examined many aspects of the user-system relationship to gain insight into user acceptance. Ives and Olson (1984), Hartwick and Barki (1994), and McKeen, Guimaraes, and Wetherbe (1994) investigated the correlation between user involvement in the development process and user acceptance. In addition, others have examined how the cognitive style of the individual user has been considered as a factor in acceptance (Huber, 1983). Additionally, the effect of user beliefs and attitudes on actual system use has received much attention (Ives, Olson, and Baroudi, 1983:785-793; Davis and others, 1989). Furthermore, innovation diffusion theory has also been referenced to illuminate the acceptance of information technology and determinants of technology adoption within user communities (Rogers, 1995).

MIS Conceptualization of Acceptance

As yet, no single factor has emerged as a reliable predictor of user acceptance (Dillon and Morris, 1996:5). But this is not to say that understanding of user acceptance has not been furthered. Rather than a single-factor predictor of user acceptance, multi-factor theories have risen from user acceptance research.

Theory of Reasoned Action (TRA). The Theory of Reasoned Action (Ajzen and Fishbein, 1980) is a widely studied model that focuses on the determinants of intended behaviors. The Theory of Reasoned Action (TRA) posits that an individual's behavioral intent (BI) or intention to act is a good predictor of actual behaviors. BI is influenced by the individual's attitude (A) and subjective norm (SN). Figure 2 shows a diagram of TRA.

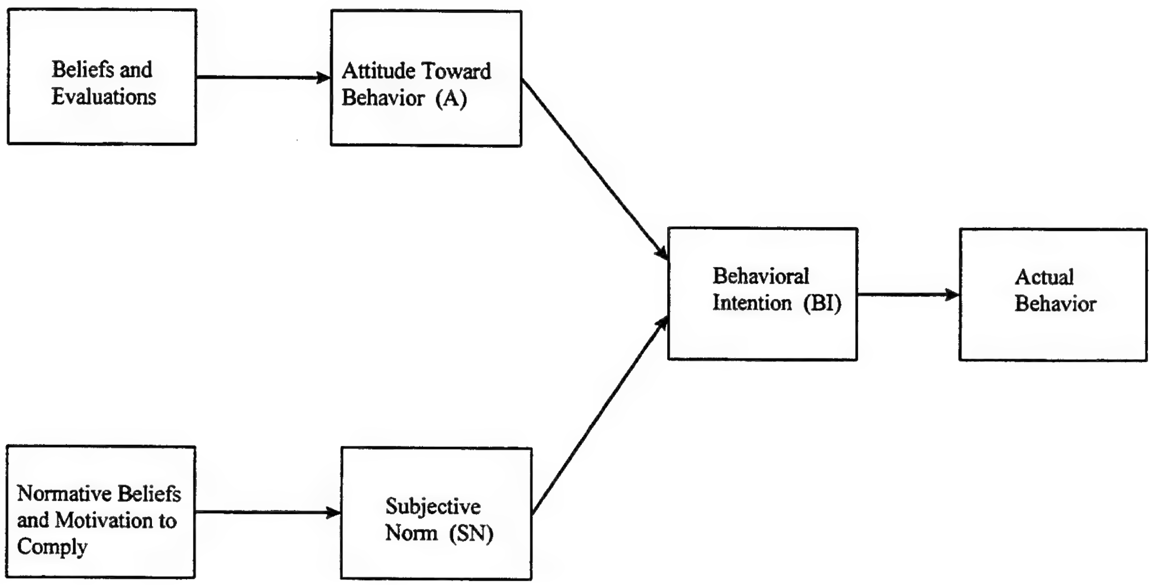


Figure 2. The Theory of Reasoned Action (TRA) Model

Beliefs and evaluations (upper left box) are defined as the level of an individual's subjective confidence that a given action will produce a given result, and an evaluation of the desirability of that result (Davis and others, 1989:984). For example, individuals needing to solve simultaneous equations may believe that using a programmable calculator will be faster and more flexible than using a spreadsheet program loaded on their desktop computers. The increased flexibility will allow them to complete work

while riding the subway, instead of spending after-hours time in the office, hence arriving home earlier. The belief that the action will lead to the result and the evaluation of the result (arriving home earlier) will affect the Attitude Toward Behavior. Attitude Toward Behavior denotes the consequential subjective attitude formed by belief in the likelihood and desirability of the consequences of a given action. Attitude Toward Behavior is one of the two determinants of Behavioral Intent (BI) (Ajzen and Fishbein, 1980).

According to Davis and others (1989:984),

> A particularly helpful aspect of TRA from an IS perspective is its assertion that any other factors that influence behavior do so only indirectly by influencing A, SN, or their relative weights. TRA captures the internal psychological variables through which numerous external variables studied in IS research achieve their influence on user acceptance.

A significant body of research indicates that A and SN mediate the effect of external variables on BI (Bagozzi, 1984; Warshaw and Davis, 1985, 1986).

Technology Acceptance Model (TAM). Although TRA has received reliable empirical support, it is a general model. Davis (1989) adapted TRA for use in IS research, especially for study in the area of user acceptance. The adaptation, referred to as the Technology Acceptance Model (TAM) is pictured below.

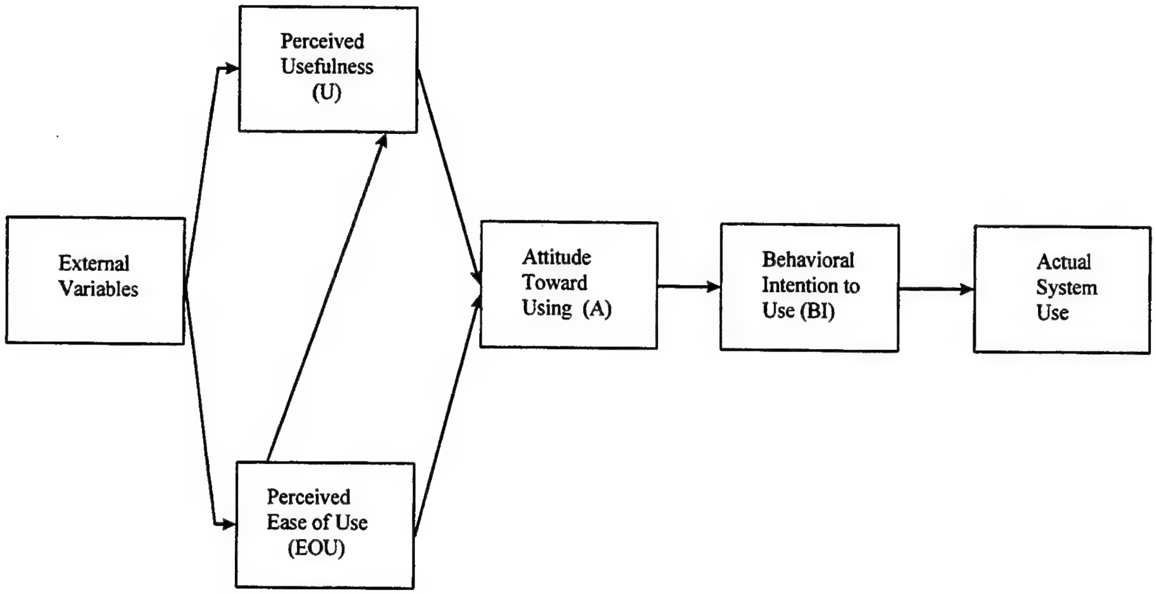


Figure 3. Technology Acceptance Model (TAM)

Research has confirmed that Behavioral Intent (BI) is the single best predictor of actual use (Taylor and Todd, 1995:144-176). TAM describes the relationships between the attitudes and beliefs that form BI. In TAM, BI is modeled as a function of Perceived Usefulness (U) and Perceived Ease of Use (EOU); and TAM posits that U and EOU are primary factors in computer acceptance behaviors. U is defined as the degree to which the prospective user believes that use of a specific application system will increase his or her performance. EOU is defined as the degree to which the prospective user believes that use of a specific system will be free of effort (Davis and others, 1989:985; Dillon and Morris, 1996:10). Furthermore, it is posited in TAM that external variables (EV), which may include such items as system features (mice, menus, graphical user interface), training, documentation and user support, can also influence EOU (Davis and others, 1989:987-988).

TAM has emerged as an effective tool in predicting user acceptance. Extensive empirical support for the model exists e.g., Adams, Nelson, and Todd, 1992; Chin and Todd, 1995; Davis and Venkatesh, 1995; and Davis and Venkatesh, 1996. While a significant body of research supports the validity and robustness of TAM, its generality has not yet provided adequate predictive knowledge for use by system designers. In recent work, Davis recognizes that this outcome "while being very powerful in helping us predict acceptance, one of the limitations of TAM is that it does not help understanding and explain acceptance in ways that guide development" (Venkatesh and Davis, 1996:472). Further, according to Venkatesh and Davis (1996:452), the preponderance of TAM research has focused on U and EOU, with little research dedicated to understanding the determinants of EOU.

Antecedents of EOU. Figure 3 shows EOU modeled as a function of External Variables (EV). According to Davis (1989:987-989), a key purpose of TAM is to provide a basis for tracing the impact of external factors on internal attitudes. Little research has focused specifically on the antecedents and determinants of EOU, namely, the EVs. However, the antecedents that have been suggested include Perceived Behavioral Control (Ajzen, 1985; Mathieson, 1991), Enjoyment, Computer Self-Efficacy, Objective Usability, Computer Anxiety (Venkatesh and Davis, 1996; Venkatesh, 1998 under review). A pictorial representation of these antecedents is presented in Figure 4.

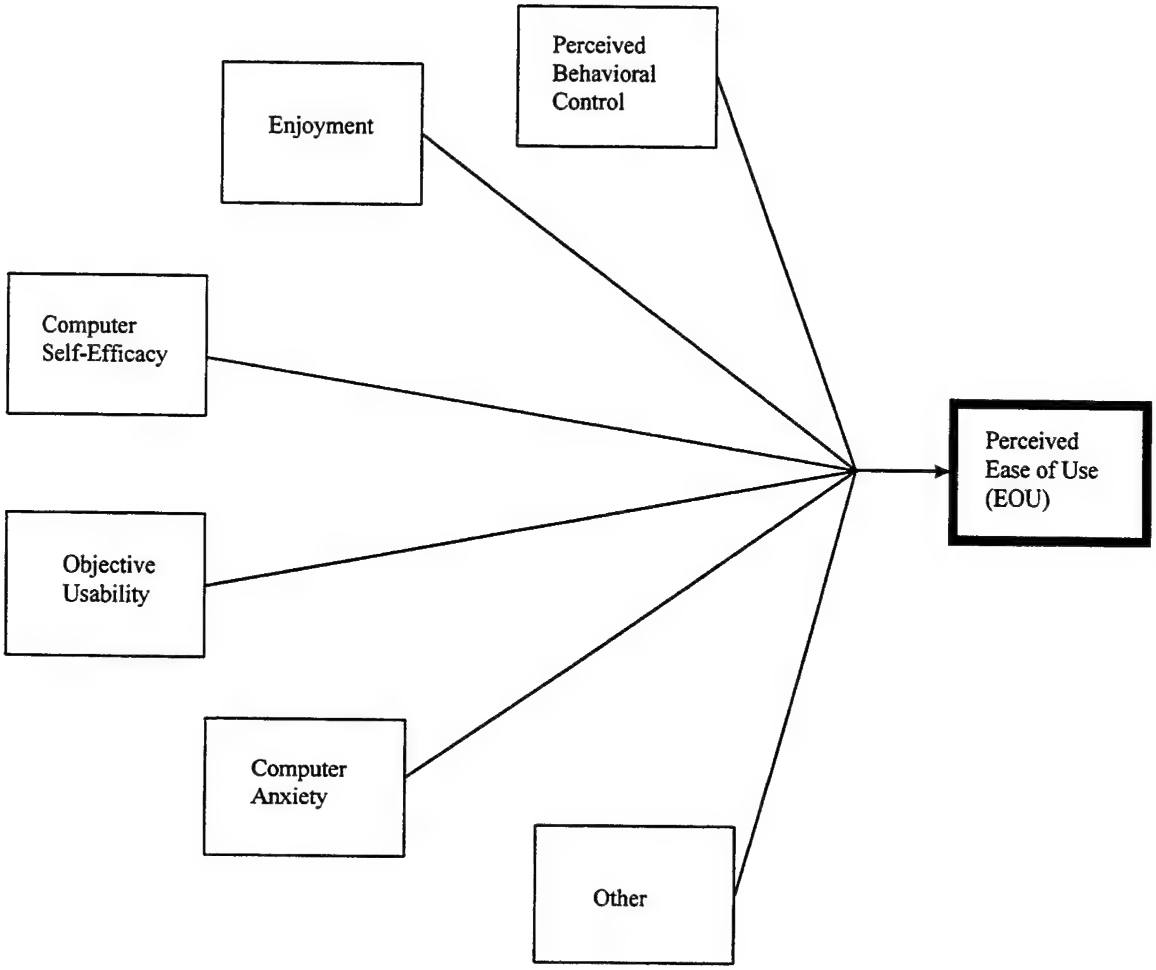


Figure 4. Antecedents of EOU

Perceived Behavioral Control (PBC) is a construct that describes the relationship between enabling aspects of the environment (knowledge, available resources, and opportunities) and behavior (Azjen, 1985:11-39). PBC is determined by control beliefs and perceived facilitation. Control beliefs pertain to the perceptions of availability of knowledge, resources, and opportunities. Perceived facilitation relates to the perceived importance of these on the desired outcomes.

With respect to information systems, enjoyment has been defined as "the extent to which the activity of using the computer is perceived to be enjoyable in its own right,

apart from any performance consequences that may be anticipated" (Davis and others, 1992:1113). Further, recent research by Venkatesh (1998) suggests that higher levels of enjoyment lead to lowered perceptions of effort—or higher levels of perceived ease of use.

Self-Efficacy, defined as "judgments of how well one can execute courses of action required to deal with prospective situations" (Bandura, 1982) is important to the formulation of EOU. In general applications, it has been demonstrated that self-efficacy influences the decisions to use a particular computer, independent of the perceived instrumental value of the system (Hill, Smith and Mann, 1987). Specific to TAM, research has supported the proposition that Computer Self-Efficacy, the application of self-efficacy theory to computer systems, is an antecedent of EOU (Venkatesh and Davis, 1996).

Objective Usability has been proposed as an antecedent of EOU (Venkatesh and Davis, 1996). In the MIS vernacular, Objective Usability represents an objective measure of system characteristics. Accomplished through operationalizing the facet of interest, Objective Usability provides a means for comparisons among systems. The construct of Objective Usability has long existed in the Human-Computer Interaction context (Shackel and Richardson, 1991:24-25), where usability inspection (Mark and Nielsen, 1994) has been evolved into a recognized methodology. The high-level objectives of understanding usability issues are to identify potential usability problems and to develop design-relevant knowledge that is useful in improving usability (Mark and Nielsen, 1994:1.4)

Computer Anxiety consists of the fear or apprehension that individuals may experience when confronted with possibility of using a computer (Simonson, Mauer, Montag-Torardi, and Whitaker, 1987:232). It has been postulated that computer anxiety negatively affects perceived EOU (Venkatesh, 1998 under review).

Human-Computer Interaction Perspective

The field of Human-Computer Interaction (HCI), a subset of the Human-System Interaction discipline, focuses on computer use issues, to include Human Factors and Ergonomics (Shackel and Richardson, 1991:12-13). System acceptance by users is one of the central themes and research focuses of HCI. By analytical consideration of all aspects of a system with which users interact, HCI seeks to understand and enumerate the factors that contribute to user acceptance of systems (Nielsen, 1993:24-25). The theoretical construct of system acceptance has been encapsulated by Shackel (1991:22) in an acceptability equation. The equation states:

> {UTILITY (will it do what is needed functionally?) + USABILITY (will the users actually work it successfully?) + LIKEABILITY (will the users *feel* it is suitable?)}
>
> must be balanced in a trade-off against
>
> COST (what are the capital and running costs?, what are the social and organizational consequences?)
>
> to arrive at a decision about
>
> ACCEPTABILITY (on balance the best possible alternative for purchase)

It should be noted that this paradigm places the same importance on usability as it places on functionality requirements. It must be understood that simply providing the user with the facilities to perform tasks helps little if the user does not employ the system effectively, cannot find the functions, or avoids systems use for various reasons.

Usability Defined. A variety of theoretical and working definitions for usability can be found in the HCI literature. Representative definitions follow.

--Usability typically refers to the following three characteristics: speed, accuracy, and satisfaction (Hoffer, George, and Valacich, 1996:490).

--*User friendliness* should be replaced with "Time to learn, Speed of performance, Rate of errors by users, Retention over time, and Subjective satisfaction" (Shneiderman, 1992:15-19).

--"The capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks , within the specified range of environmental scenarios" (Shackel, 1991:24).

--And according to Nielsen (1993:26), "Usability has multiple components an is traditionally associated with these five usability attributes: Learnability, Efficiency, Memorability, Errors, and Satisfaction."

--"According to ISO 9241 pt. 11 the usability of an application refers to the effectiveness, efficiency, and satisfaction with which specific users who are performing specific tasks in specific environments can use an application" (Dillon and Morris, 1996:20).

At the heart of the system acceptance model, usability issues focus on the central user-centered design question, "Will they use it?" Figure 5 is an adaptation of an acceptability model that illustrates the role of usability in system acceptance (Nielsen, 1993:25). The model presents the attributes of system acceptability and the relationships between the varied factors.

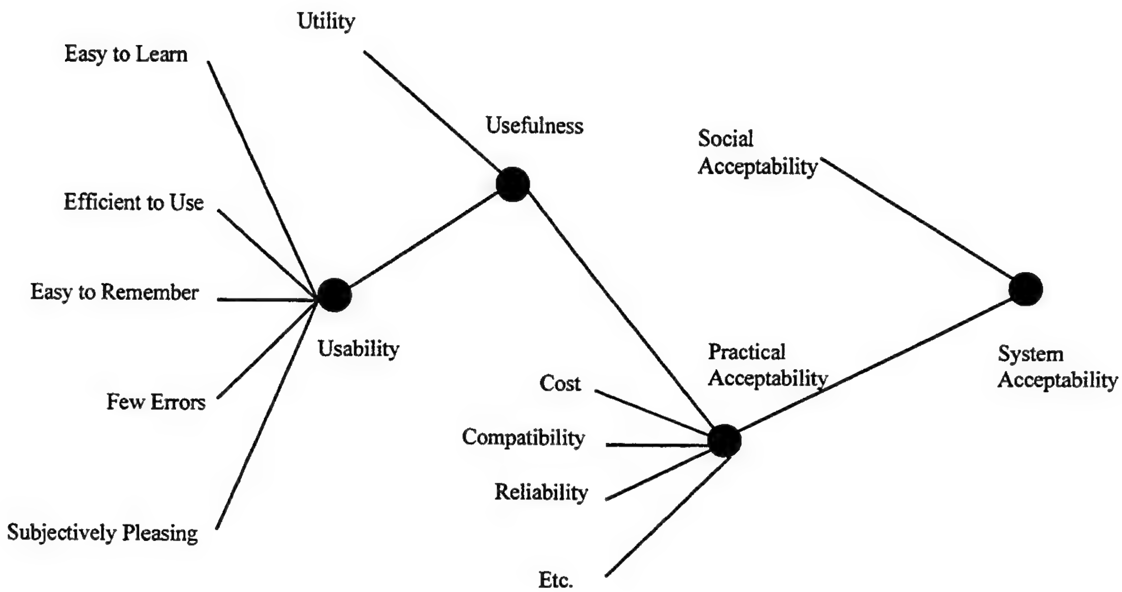


Figure 5. A Model of the Attributes of System Acceptability

The emergence of usability as a critical design criteria is emphasized by the International Standards Organization (ISO) introduction of a new international standard (ISO 9241) that covers usability in software and systems (Dillon, 1994). A large volume of work exists (Nielsen, 1993; Shneiderman, 1992; Shackel and Richardson, 1991) explicating the relationship between usability and user interface, indicating that the user's objective experiences with a system lead to the formation of perceptions about the

system. At this point it is useful to recall that TAM describes the mediating effect EOU has on the relationship between external variables and perceptions of the system. According to Davis, et al, (1989), system design aspects, such as the user interface, lead to EOU perceptions.

Integrating MIS and HCI Research

As stated in chapter one, it is the purpose of this thesis to relate the HCI system acceptability model and the MIS technology acceptance model. Specifically, this thesis proposes to correlate the theoretical constructs of usability from the HCI model and EOU from the MIS model. Further, it will investigate how utility from the HCI model correlates with U (usefulness) from the MIS model. Thus, given these alternatives perspectives, the following proposition is offered:

The user's cognitive experience with the technology, in terms of effectiveness, efficiency, and satisfaction significantly influence the formation of EOU perceptions.

III. Method

Research Approach

This chapter presents details of the experiment and data gathering. The experiment was conducted in a laboratory setting at a large university. Two popular word processing software packages were used to assess objective usability and perceived ease of use. The following sections describe the sample, design and measures for this study in detail.

Sample. The participants in the experiment were freshmen and sophomores enrolled in a required class at a large, midwestern university. Students were required to participate in graduate research to fulfill course requirements. Although participation in research was a requirement, students were able to choose from a variety of research projects.

Design. The two word processing software packages used in the experiment were Word for Windows and WordPerfect 5.1 (DOS version). These two software packages were chosen because of their popularity, and because both word processors were already installed in the university computer labs. The participants were prescreened to sort the participants into two groups; Word users and WordPerfect users. All participants had previous experience with one or both word processors. Participants with Word experience were placed in the group that used Word in the experiment, and participants

with WordPerfect experience were placed in the group that used WordPerfect in the experiment.

The participants were provided with a hardcopy of a two-page, multi-paragraph text document that incorporated commonly found features of word processing, e.g., underlining, bolded text, italics, text centering, and various font sizes. A text file containing only the text (no formatting, spacing, etc.) of the document was provided on a floppy disk. Participants were instructed to use the word processor to edit the text file and strive to produce an exact copy, or copy as closely as possible the sample document. Instructions indicated that the copy should incorporate the same fonts, features and text of the sample document. All instructions were conveyed verbally and each participant received written instructions. Additionally, participants were given the following hints in the written instructions:

-font is Univers

-title size is 14 point, everything else is 12 point

-margin is 1 inch on top, bottom , left and right

-all double and triple space locations were identified

Participants were allowed to work at their own paces. Times for each participant to complete the task was recorded. After completion of the document, participants completed questionnaires designed to elicit participants' reactions to the word processor they had used. The questionnaire is discussed in the next section.

Measures. Consistent with the literature on usability assessment, measures of effectiveness, efficiency, and satisfaction were gathered to assess system usability. In

addition, measures of EOU and U from the MIS literature were gathered to help understand the nomological net associated with the usability construct. Reproduction of the text page was graded with a nine-point criteria to measure accuracy. This measurement leads to an effectiveness score. The questionnaire contained a variety of measuring instruments (see Table 1). Additionally, the reproduced text was graded as an operationalized measure of accuracy and task completion.

Table 1. Measurement Instruments

Effectiveness	Efficiency	Satisfaction	MIS
Accuracy Task Completion	Time TLX	QUIS	EOU U

The reproduced document was graded using a nine-point criteria that reflected the accuracy of the reproduction. The nine criteria used were not weighted, and were each worth one point. The highest possible score was 9, and the lowest possible score was 0. The criteria were:

-selecting the correct font type

-selecting the correct font size for the title

-selecting the correct font size for the body

-centering the title

-bolding the headings

-underlining the headings

-correct use of italics

-correct line spacing

-correct margins

The EOU scale (Davis, 1989) consisted of four items. The participants indicated the degree of EOU on a 7-point Likert scale. A response of 1 indicated strongly disagree, 4 indicated neutral (neither agree nor disagree), 7 indicated strongly agree. The measure of EOU is derived by adding the scores on each of the EOU items and dividing by four to provide an overall index of EOU.

The perceived usefulness scale used in this study has demonstrated strong reliability and internal consistency (Davis, 1989). The U scale consists of four items indicative of the construct. As with EOU, the participant was asked to indicate the degree of U on a 7-point Likert scale. A response of 1 indicated strongly disagree, 4 indicated neutral (neither agree nor disagree), and 7 indicated strongly agree. Individual measures of U were derived by adding the scores on each of the U items and dividing by four to provide an overall index of U.

Satisfaction was measured by coding the QUIS into the questionnaire. The five components of satisfaction measured by the QUIS were:

-overall reaction to the system

-screen

-terminology

-learning

-system capabilities

Individual scores for the five components were obtained by averaging the component responses.

Measurement of subjective mental workload (SMW) was achieved through use of the TLX. The TLX has been used extensively in human factors research and is considered to be one of the best measures of SMW available (Hancock and Meshkati, 1988:139). The TLX employs a pair-wise comparison of six dimensions. The six dimensions are:

-mental demand

-physical demand

-time demand

-performance

-effort

-frustration level

In addition to the pair-wise dimensions, TLX employs a scaled rating of each of the five dimensions with ratings ranging from 0 to 100. Calculation of the mental workload scores involved tallying the times each dimension was identified in the pair-wise comparisons. Each dimension could be identified from 0 to 5 times. The pair-wise comparison score was then multiplied by the corresponding scaled rating. This product led to a sum that was divided by 15 to produce a workload score (Hancock and Meshkati, 1988:177).

Statistical Analysis. The data collected were analyzed using a variety of statistical techniques including descriptive statistics, normality tests, t-tests, and multiple

regression. Descriptive statistics such as means and standard deviations are used to prepare the data for further analysis and provide a general idea of the ranges and trends of the data. Paired t-tests are used to indicate the validity of the samples and hence the comparisons of the samples. Finally, the factors described in Chapters I and II were tested using multiple regression to determine significant factors impacting U and EOU. A copy of the questionnaire used in this study is found in the appendix to this thesis. The questionnaire appended is for Word; the WordPerfect questionnaire was identical except that it referenced WordPerfect rather than Word.

IV. Results

Results

The results of the procedures described in the preceding chapter are reported here. The data were coded and reduced for analysis as appropriate for the various measurement instruments. First, data for the two groups (Word and WordPerfect) were analyzed and compared. Finally, data for the two groups was combined into a single data set which yielded a predictive model based on regression analysis. Data reduction and analysis have yielded the findings encapsulated in Tables 1 through 8.

Overall Results. The results shown in Tables 1 and 2 (below) show the Pearson correlations of all variables and all dimensions of all variables for the two groups (Word for Windows and WordPerfect, respectively). The variables QUIS and TLX are each comprised of several dimensions. Tables 1 and 2 present results in which each dimension is visible. For clarity, lines have been added between the variables, and dimensions of variables have been indented.

The variables shown include Usefulness (U), Ease of Use (EOU), Questionnaire on User Interface Satisfaction (QUIS), NASA Task Load Index (TLX), Accuracy (ACCUR), and Time. QUIS is comprised of five dimensions; Overall Reaction (REACT), Screen, Terminology (TERM), Learning (LEARN), and Systems Capabilities (SYS). TLX is comprised of six dimensions; Mental Demand (MD), Physical Demand (PD), Time Demand (TD), Performance (PERF), Effort (EFF), and Frustration Level (FRUS). It should be noted from Tables 1 and 2 that the dimensions of TLX (measure of subjective mental workload) and the dimensions of QUIS (measure of satisfaction) are

highly correlated with the overall variables of TLX and QUIS, respectively. An exception to the this high level of correlation is found is the relatively low correlations between TLX and the dimension of PD (physical demand). The low correlation is not unexpected in light of the relatively low physical demands placed on the participants, e.g., using a desk top computer located in a computer laboratory. However, the overall picture suggests that these measures are, in fact, measuring a single (multi-dimensional) construct.

Table 2. Correlations (Pearson) of Variables and Dimensions, Word

	U	EOU	REACT	SCREEN	TERM	LEARN	SYS
EOU	0.4104						
REACT	0.2473	0.3834					
SCREEN	0.1033	0.4416	0.2296				
TERM	0.0587	0.4135	0.3188	0.8358			
LEARN	0.1538	0.5175	0.4217	0.6027	0.6818		
SYS	0.1993	0.4314	0.5336	0.4825	0.5662	0.5118	
QUIS	0.2091	0.5580	0.7236	0.7683	0.8334	0.8028	0.7615
MD	-0.0930	-0.4154	-0.2636	-0.0771	-0.1838	-0.1131	-0.1939
PD	-0.1242	-0.2453	0.1917	-0.0889	-0.1956	-0.0824	-0.0444
TD	-0.2938	-0.3745	-0.1158	-0.0379	-0.0644	-0.2043	-0.2185
PERF	-0.3174	-0.5230	-0.2195	-0.1861	-0.2598	-0.3762	-0.2008
EFF	-0.1288	-0.2927	-0.3390	-0.0900	-0.2147	-0.1971	-0.0531
FRUS	-0.3649	-0.5203	-0.1960	-0.0824	-0.0609	-0.0352	-0.1367
TLX	-0.2723	-0.4537	-0.2252	-0.0959	-0.2047	-0.1935	-0.1717
ACCUR	0.1791	0.3178	-0.2021	-0.0174	-0.0560	0.0164	-0.1718
TIME	-0.2301	-0.3713	-0.2060	-0.2849	-0.2558	-0.1202	-0.1593

	QUIS	MD	PD	TD	PERF	EFF	FRUS
MD	-0.2283						
PD	-0.0191	0.2638					
TD	-0.1559	0.5531	0.3621				
PERF	-0.3182	0.4154	0.2680	0.3984			
EFF	-0.2642	0.7104	0.0809	0.5399	0.4246		
FRUS	-0.1457	0.5661	0.2774	0.5065	0.3373	0.4897	
TLX	-0.2373	0.8258	0.2774	0.7517	0.6781	0.8381	0.6527
ACCUR	-0.1245	0.0244	-0.0902	-0.0254	-0.2329	-0.0549	-0.1674

Table 2. (Continued)

TIME	-0.2713	0.2789	0.2376	0.3097	0.3336	0.3306	0.5015

	TLX	ACCUR
ACCUR	-0.1461	
TIME	0.3995	0.0285

Table 3. Correlations (Pearson) of Variables and Dimensions, WordPerfect

	U	EOU	REACT	SCREEN	TERM	LEARN	SYS
EOU	0.2305						
REACT	0.5132	0.5751					
SCREEN	0.4681	0.2129	0.5002				
TERM	0.5993	0.5157	0.6980	0.6024			
LEARN	0.3481	0.6568	0.5275	0.3938	0.6130		
SYS	0.2815	0.3715	0.5361	0.5395	0.5072	0.6782	
QUIS	0.5591	0.5655	0.8202	0.7758	0.8557	0.7695	0.7977
MD	0.0748	-0.3456	-0.1278	0.0367	-0.2696	-0.0726	0.1842
PD	-0.1035	-0.1167	-0.0245	-0.3862	-0.0161	0.1226	0.0431
TD	-0.0796	-0.3663	-0.2131	-0.2062	-0.2533	-0.0280	0.0929
PER	0.1030	-0.3444	-0.3263	-0.1944	-0.1515	-0.1273	-0.0950
EFF	0.0832	-0.2904	-0.0347	0.0414	-0.0504	-0.0405	0.1356
FRUS	-0.2113	-0.5817	-0.5658	-0.3441	-0.4887	-0.2610	-0.0430
TLX	0.0339	-0.4769	-0.2388	-0.0761	-0.2242	-0.0656	0.1009
ACCUR	0.2374	0.4801	0.4765	0.1862	0.2391	0.2137	0.2110
TIME	0.1811	-0.2981	-0.2876	0.1380	-0.1086	-0.0047	-0.0030

	QUIS	MD	PD	TD	PER	EFF	FRUS
MD	-0.0641						
PD	-0.0843	0.1627					
TD	-0.1637	0.5340	0.6597				
PER	-0.2289	0.4377	0.0529	0.2435			
EFF	0.0134	0.7896	0.1462	0.3996	0.6258		
FRUS	-0.4361	0.5624	0.4337	0.6312	0.4488	0.4505	
TLX	-0.1322	0.8078	0.3354	0.6522	0.7192	0.8727	0.7509
TEXT	0.3342	-0.1006	-0.2736	-0.4420	-0.2892	-0.1151	-0.5302
TIME	-0.0680	0.4211	0.0593	0.4979	0.3308	0.2259	0.3566

Table 3. (Continued)

	TLX	TEXT
TEXT	-0.4015	
TIME	0.4249	-0.4473

Subsequent presentation of correlations provides information on TLX and QUIS as overall variables, without specific reporting on the internal dimensions. Given the high correlations among the internal dimensions of the QUIS and TLX, the analyses which follow use only the overall measures of satisfaction (QUIS) and subjective mental workload (TLX), respectively.

Table 4. Correlations (Pearson) of Variables, Word

	U	EOU	QUIS	TLX	ACCUR
EOU	0.4104				
QUIS	0.2091	0.5580			
TLX	-0.2723	-0.4537	-0.2373		
ACCUR	0.1791	0.3178	-0.1245	-0.1461	
TIME	-0.2301	-0.3713	-0.2713	0.3995	0.0285

The correlations shown in Table 3 provide several results of interest. The correlation between QUIS and EOU may indicate the role that satisfaction plays in forming EOU perceptions. As expected, mental workload (TLX) correlated negatively with U and EOU, suggesting that as mental workload increased, perceptions of usefulness and ease of use decreased. Additionally, a negative correlation between TIME (time required for the task) EOU was observed. This negative correlation indicates that as the time required to complete the task increased, the formulation of perceived EOU decreased.

Table 5. Correlations (Pearson) of Variables, WordPerfect

	U	EOU	QUIS	TLX	ACCUR
EOU	0.2305				
QUIS	0.5591	0.5655			
TLX	0.0339	-0.4769	-0.1322		
ACCUR	0.2374	0.4801	0.3342	-0.4015	
TIME	0.1811	-0.2981	-0.0680	0.4249	-0.4473

The results for WordPerfect (Table 4) are similar to those for Word. One difference in Table 4 is the strong relationship between QUIS and U. This may indicate a user preference for the interface or the features of this particular word processor. The version of WordPerfect used in this study was text based, required keystrokes for functions, and did not implement the modern standard of WYSIWYG (what you see is what you get) so that the document as it would be printed as it appeared on the monitor. In contrast, Word used icon menus, graphical interface, and featured WYSIWYG. Both word processors featured standard editing functions, and special tools such as spell checking.

Also, a significant correlation exists between accuracy (ACCUR) and EOU. This result is not surprising, but did not occur in the data for Word (Table 3). Finally, the data for WordPerfect (Table 4) indicates a significant negative relationship between time and accuracy. In other words, the more time the participant required, the less accurate the work. This is somewhat surprising; one possible explanation would be that some participants had difficulties using WordPerfect, or some participants spent time manually searching for and correcting errors.

Because the correlation results indicated some differences between the data for the different word processors, the researcher conducted further analysis of the data to determine whether there were mean differences between the two word processors across each of the variables. Table 5 depicts a summary of the t-test results of the six principal variables.

Table 6. t-Test Results

Variable	Word Mean(Variance)	WordPerfect Mean(Variance)	T	p
U	5.85(0.95)	5.22(0.75)	-2.48	0.02
EOU	5.81(1.01)	4.64(2.01)	-3.65	<0.01
QUIS	6.82(1.26)	5.40(1.42)	-4.71	<0.01
TLX	38.96(295.27)	47.87(388.34)	1.83	0.08
ACCUR	7.12(2.19)	5.52(4.01)	-3.29	<0.01
TIME	35.76(68.94)	39.72(63.54)	1.83	0.08

The p values reported in table 5 are for the two-tail test. The p values for the variables U, EOU, QUIS and ACCUR are significant at the 0.05 level. This indicates that there were no significant mean differences across these measures. Both TLX and TIME exhibit non-significant p values (at the 0.05 level), but they approach significance.

Given the differences between the data for the two groups, the next step was to identify which of the variables offered the most exploratory power in predicting EOU. This was accomplished by use of multiple regressions for both Word and WordPerfect. EOU was entered as the dependent variable (DV), and each of the variables U, QUIS,

TLX, ACCUR, and TIME were entered as the independent variables (IV). The method of regression was unweighted, least squares, linear regression. The results of these regressions are presented below. Tables 6 and 7 show the regression models of the two samples, Word and WordPerfect, and Table 8 shows the regression model for the combined samples.

Table 7. Linear Regression of EOU, Word

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	T	P
CONSTANT	1.39060	1.44107	0.96	0.3420
U	0.19437	0.14492	1.34	0.1896
QUIS	0.41324	0.10798	3.83	0.0006
TLX	-0.01027	0.00706	-1.45	0.1561
ACCUR	0.22081	0.08339	2.65	0.0126
TIME	-0.01525	0.01491	-1.02	0.3143

R-SQUARED	0.5775	RESID. MEAN SQUARE (MSE)	0.50745
ADJUSTED R-SQUARED	0.5094	STANDARD DEVIATION	0.71235

SOURCE	DF	SS	MS	F	P
REGRESSION	5	21.5023	4.30045	8.47	0.0000
RESIDUAL	31	15.7308	0.50745		
TOTAL	36	37.2331			

Table 8. Linear Regression of EOU, WordPerfect

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	T	P
CONSTANT	2.65602	1.94621	1.36	0.1883
U	-0.12951	0.33424	-0.39	0.7027
QUIS	0.59593	0.23711	2.51	0.0211
TLX	-0.02294	0.01315	-1.75	0.0971
ACCUR	0.13440	0.14160	0.95	0.3544
TIME	-0.00514	0.03491	-0.15	0.8844

R-SQUARED	0.5178	RESID. MEAN SQUARE (MSE)	1.22161
ADJUSTED R-SQUARED	0.3909	STANDARD DEVIATION	1.10527

Table 8. (Continued)

SOURCE	DF	SS	MS	F	P
REGRESSION	5	24.9244	4.98487	4.08	0.0110
RESIDUAL	19	23.2106	1.22161		
TOTAL	24	48.1350			

Table 9. Linear Regression of EOU, Word and WordPerfect (Combined)

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	T	P
CONSTANT	2.19768	1.23601	1.78	0.0826
U	0.07794	0.15151	0.51	0.6097
QUIS	0.52296	0.10409	5.02	0.0000
TLX	-0.01342	0.00755	-1.78	0.0828
ACCUR	0.14982	0.07596	1.97	0.0552
TIME	-0.02567	0.01798	-1.43	0.1608

R-SQUARED	0.6432	RESID. MEAN SQUARE (MSE)	0.74696
ADJUSTED R-SQUARED	0.6008	STANDARD DEVIATION	0.86427

SOURCE	DF	SS	MS	F	P
REGRESSION	5	56.5639	11.3128	15.15	0.0000
RESIDUAL	42	31.3723	0.74696		
TOTAL	47	87.9362			

The regression model for the combined data yields:

$$EOU=0.078U + 0.523QUIS - 0.013TLX + 0.150ACCUR - 0.026TIME + 2.198$$

This equation shows that QUIS is the strongest individual factor, followed by ACCUR. This finding is supported by the regressions for each of the two samples, where QUIS is significant and ACCUR was significant in Word sample. The overall regression indicates that ACCUR makes a meaningful contribution to the model, and with p=0.055 is on the boundary of significance. QUIS is clearly significant as a major factor in the model and emerges as the single best predictor of EOU. Although the role of QUIS outweighs all others in the model, it is interesting to note that the overall model delivers $R^2 = 0.643$. In

other words, this model explains 64% of the variance. While the other factors in the model do not contribute as the researcher had expected, the results certainly indicate that satisfaction (QUIS) is a strong predictor of EOU.

V. Discussion

General Discussion

The research this thesis reports on was undertaken to improve understanding of user acceptance of technology, specifically, information technology. A significant body of research in HCI has accumulated supporting the importance of effectiveness, efficiency, and satisfaction as determinants of usability. Specifically, researchers in HCI have suggested subjective mental workload, accuracy, and time for task completion as potentially useful measures for predicting system usability. Further, MIS researchers have amassed a body of evidence supporting the criticality of user perceptions. From a qualitative perspective, the notion can be forwarded that HCI has accomplished much in response to the question, "*Can users use the system?*" It can also be suggested that MIS has responded in a significant manner to the question, "*Will users use the system?*" The research reported has drawn from the theoretical framework of both the MIS and HCI fields, and attempted to find the theoretical "common ground" that lies between the two disciplines. Empirically, instruments used extensively in HCI research, QUIS and TLX, were applied to the MIS construct of perceived EOU.

The research question that motivated this researcher focuses on the formulation of perceived ease of use. The proposition formulated was:

> The user's cognitive experience with the technology, in terms of effectiveness, efficiency, and satisfaction, significantly influences the formation of EOU perceptions.

The results only partially support the proposition. The data do not support the anticipated role of efficiency and effectiveness in formulating EOU. Efficiency, operationalized as time required to complete task and subjective mental workload, did not appear to influence EOU, while effectiveness, operationalized as accuracy in completing a required task, was marginally significant. However, satisfaction emerged as a very significant determinant of EOU. This result, though somewhat unexpected, does demonstrate the existence of theoretical constructs that may be shared across both HCI and MIS.

The mixture of validated instruments accepted in both the HCI and MIS arenas made possible the construction of a model that successfully predicts formulation of EOU. On a positive note, the full model (including effectiveness, efficiency, and satisfaction) was able to account for 64% of the variance in EOU. While individual "pieces" were not always significant, the entire model did provide a good fit to the data. As mentioned earlier, the most important predictor was satisfaction, measured by the QUIS, which accounted for 52% of the variance in EOU.

The data indicate that efficiency and effectiveness do not play a significant role in EOU formulation. One explanation for this result could be that these results were affected by factors peculiar to this study, such as the dissimilar user interfaces used by the two groups, or self-selection variables associated with the sample groups. (Word employed the modern WYSIWYG standard and a graphical interface. WordPerfect employed a text based, keystroke, non-WYSIWYG interface).

The fundamental problem approached by this research is that of predicting system usability and overall acceptability by users. To date, no single factor has emerged as a

reliable predictor of acceptance. Yet the results reported here suggest that satisfaction should be considered as a significant factor in future research.

Implications

The significance of satisfaction in forming EOU has theoretical implications. Interestingly, satisfaction has not previously been incorporated into the most widely known model of technology acceptance in the MIS literature, TAM (see Davis and others, 1989). This research suggests that extending TAM to include satisfaction as an important construct should be considered. The acceptance of satisfaction into the technology acceptance nomological net may augment our current understanding of user acceptance.

The significance of these findings have practical implications as well. MIS practitioners often struggle to find and use instruments that will accurately predict acceptance of information technology. If MIS managers are able to predict user acceptance before a system is deployed, they can take additional actions, as needed, to enhance user acceptance. These actions could include additional training, improved documentation, or other actions that are warranted. The evidence in this study suggests both that satisfaction is a variable that may be useful, and that the HCI instrument, QUIS, may be useful in measuring satisfaction. This has significant implications for the practitioner making usability evaluations with limited resources. The QUIS is relatively inexpensive to administer, and appears to reliably predict EOU.

These findings may also be useful in development of systems, especially within the rapid-prototyping approach, in which prototypes are quickly produced, evaluated, and

modified. QUIS could provide a developer with a quick-look of usability prior to full commitment to a particular design.

Limitations

As with all research, there are a number of limitations inherent in this study. First, the samples used for the study were drawn from undergraduates at a large university. These students were all experienced with personal computers, in general, and word processors, specifically. Different results may be obtained with samples that have less experience or computer knowledge. Furthermore, the use of word processors as a medium may not generalize to other software applications. Also, the task performed in the study was a relatively short, uncomplicated task. Advanced techniques, such as graphics integration, tables, etc., were not part of the task. A more complex task might cause effectiveness and efficiency to be more salient to users (and thereby significant in prediction of EOU). Finally, because of the self-selection element of the study, the sample size for the WordPerfect sample was 25. While this was thought to be adequate to test the proposition central to this study, a larger sample may have yielded greater statistical power, causing those variables which were only marginally significant to reach statistical significance at the alpha = .05 level.

Conclusion

The findings of this study are significant to theorists and practitioners alike. The emergence of satisfaction, as a powerful predictor of EOU is notable. Use of well accepted HCI and MIS instruments together to build a data model that predicts EOU,

accounting for 64% of the variance strongly suggests that both MIS and HCI bring important perspectives that are useful in understanding human interaction with information technology. The use of HCI instruments to obtain data useful to predicting EOU may be a first step in building a bridge between the HCI perspective of *"can they use?"* and the MIS perspective of *"will they use?"* More research is recommended to explore the overlap in the theoretical landscape that lies between HCI and MIS.

Appendix: Word Processing Software Questionnaire

Student ID Number ______ - ____ - ___________

Part 1: For questions 1-3, please circle the best response.

1. Sex

   a) Male
   b) Female

2. How long have you been using Word for Windows?

   a) Less than 6 months
   b) At least 6 months, but less than 1 year
   c) At least 1 year, but less than 2 years
   d) 2 years or more

3. On average, how many hours per week do you use Word for Windows?

   a) Less than 1 hour per week
   b) At least 1 hour, but less than 5 hours per week
   c) At least 5 hours, but less than 10 hours per week
   d) 10 hours per week or more

Part 2: For questions 4 - 11 below, please circle the number which best indicates your opinion about the software that you just used.

4. Using Word for Windows improves my performance in my classwork.

Stongly	+3	+2	+1	0	-1	-2	-3	Strongly
Agree								Disagree

5. Using Word for Windows in my classwork increases my productivity.

Stongly	+3	+2	+1	0	-1	-2	-3	Strongly
Agree								Disagree

6. Using Word for Windows enhances my effectiveness in my classwork.

Stongly Agree	+3	+2	+1	0	-1	-2	-3	Strongly Disagree

7. I find Word for Windows useful in my classwork.

Stongly Agree	+3	+2	+1	0	-1	-2	-3	Strongly Disagree

8. I find it easy to get Word for Windows to do what I want it to do.

Stongly Agree	+3	+2	+1	0	-1	-2	-3	Strongly Disagree

9. My interaction with Word for Windows is clear and understandable.

Stongly Agree	+3	+2	+1	0	-1	-2	-3	Strongly Disagree

10. Interacting with Word for Windows does not require a lot of my mental effort.

Stongly Agree	+3	+2	+1	0	-1	-2	-3	Strongly Disagree

11. I find Word for Windows easy to use.

Stongly Agree	+3	+2	+1	0	-1	-2	-3	Strongly Disagree

For questions Parts 3-7, please circle the number that best corresponds to your opinion about the software you just used.

PART 3: Overall User Reactions

Please circle the numbers which most appropriately reflect your impressions about using this word processing system. Not Applicable = NA.

3.1	Overall reactions to the system:	terrible	wonderful	
		1 2 3 4 5 6 7 8 9		NA
3.2		frustrating	satisfying	
		1 2 3 4 5 6 7 8 9		NA
3.3		dull	stimulating	
		1 2 3 4 5 6 7 8 9		NA
3.4		difficult	easy	
		1 2 3 4 5 6 7 8 9		NA
3.5		inadequate power	adequate power	
		1 2 3 4 5 6 7 8 9		NA
3.6		rigid	flexible	
		1 2 3 4 5 6 7 8 9		NA

PART 4: Screen

4.1	Characters on the computer screen	hard to read ... easy to read	1 2 3 4 5 6 7 8 9	NA
4.2	Was the highlighting on the screen helpful?	not at all ... very much	1 2 3 4 5 6 7 8 9	NA
4.3	Were the screen layouts helpful?	never ... always	1 2 3 4 5 6 7 8 9	NA
4.4	Sequence of screens	confusing ... clear	1 2 3 4 5 6 7 8 9	NA

PART 5: Terminology and System Information

5.1	Use of terms throughout system	inconsistent ... consistent	1 2 3 4 5 6 7 8 9	NA
5.2	Does the terminology relate well to the work you are doing?	unrelated ... well related	1 2 3 4 5 6 7 8 9	NA
5.3	Messages which appear on screen	inconsistent ... consistent	1 2 3 4 5 6 7 8 9	NA
5.4	Messages which appear on screen	confusing ... clear	1 2 3 4 5 6 7 8 9	NA
5.5	Does the computer keep you informed about what it is doing?	never ... always	1 2 3 4 5 6 7 8 9	NA
5.6	Error messages	unhelpful ... helpful	1 2 3 4 5 6 7 8 9	NA

PART 6: Learning

6.1	Learning to operate the system	difficult ... easy	1 2 3 4 5 6 7 8 9	NA
6.2	Exploration of features by trial and error	discouraging ... encouraging	1 2 3 4 5 6 7 8 9	NA
6.3	Remembering names and use of commands	difficult ... easy	1 2 3 4 5 6 7 8 9	NA
6.4	Can tasks be performed in a straight-forward manner?	never ... always	1 2 3 4 5 6 7 8 9	NA
6.5	Help messages on the screen	confusing ... clear	1 2 3 4 5 6 7 8 9	NA
6.6	Supplemental reference materials	confusing ... clear	1 2 3 4 5 6 7 8 9	NA

PART 7: System Capabilities

7.1	System speed	too slow ... fast enough	1 2 3 4 5 6 7 8 9	NA
7.2	How reliable is the system?	unreliable ... reliable	1 2 3 4 5 6 7 8 9	NA
7.3	System tends to be	noisy ... quiet	1 2 3 4 5 6 7 8 9	NA
7.4	Correcting your mistakes	difficult ... easy	1 2 3 4 5 6 7 8 9	NA
7.5	Are the needs of both experienced and inexperienced users taken into consideration?	never ... always	1 2 3 4 5 6 7 8 9	NA

In addition to the questions above, we would also like to know about the workload you experienced in performing this editing task. However, feelings of workload can come from several different factors. For example, some people feel that mental or time demands are the most important factors in perceived workload. Others may feel that their performance or amount of frustration is the most important part of their feelings of workload.

The following section will present you with a series of pairs of rating scale titles (for example, Effort vs. Mental Demands). You will be asked to choose which of the items was more important to <u>your</u> experience of workload in the editing task that you just performed. Titles and descriptions of the scale titles are presented below:

<u>Title</u>	<u>Endpoints</u>	<u>Descriptions</u>
Mental Demand	Low/High	How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical Demand	Low/High	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Time Demand	Low/High	How much time pressure did you feel due to the rate or pace at which the tasks occurred? Was the pace slow and leisurely or rapid and frantic?
Performance	Good/Poor	How successful do you think you were in accomplishing the oals of the task? How satisfied were you with your performance in accomplishing these goals?
Effort	Low/High	How hard did you have to work (mentally and physically) to accomplish your level of performance.
Frustration Level	Low/High	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task.

You will be using the scale titles illustrated above in Parts 8 and 9 on the following pages. You may refer back to this table as needed.

Part 8: For each pair, circle the scale title that represents the more important contributor to workload for the editing tasks you performed in this session.

8.01. Effort or Performance

8.02. Time Demand or Effort

8.03. Performance or Frustration

8.04. Physical Demand or Performance

8.05. Time Demand or Frustration

Continued on the following page

Continued from previous page: for each pair, circle the scale title that represents the more important contributor to workload for the editing tasks you performed in this session.

8.06. Physical Demand or Frustration

8.07. Physical Demand or Time Demand

8.08. Time Demand or Mental Demand

8.09. Frustration or Effort

8.10. Performance or Time Demand

Continued on the following page

Continued from previous page: for each pair, circle the scale title that represents the more important contributor to workload for the editing tasks you performed in this session.

8.11. Mental Demand or Physical Demand

8.12. Frustration or Mental Demand

8.13. Performance or Mental Demand

8.14. Mental Demand or Effort

8.15. Effort or Physical Demand

Part 9: For questions 9.1 - 9.6, place an "X" on each scale at the point which matches your experience. Each line has two endpoint descriptors that describe the scale. Please note that Performance goes from "good" on the left side of the scale to "poor" on the right. Consider each scale individually. Your ratings will play an important role in the evaluation being conducted, therefore, your participation is greatly appreciated.

9.1. Mental Demand

Low High

9.2. Physical Demand

Low High

9.3. Time Demand

Low High

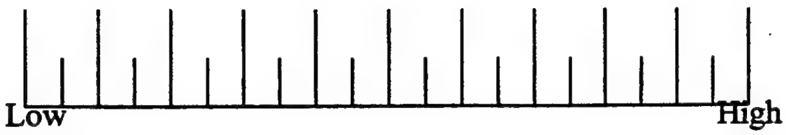
9.4. Performance

Good Poor

9.5. Effort

Low High

9.6. Frustration



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13. ABSTRACT (*Maximum 200 Words*)

In recent years, information technology has advanced at a pace that few would have anticipated. It has been estimated that the computing power of the modern desktop computer has been increasing at the rate of 1000% per decade. In combination with the development of personal computers, the advent of networks and the world wide web provide unprecedented access to information and computing power. However, the problem of developing useful user interfaces remains a problem. In many military and commercial settings, the increased computing power offered by current information technology remains unexploited because of user interfaces that are difficult to use.

This thesis reports on the examination of constructs related to user acceptance of information systems from two disciplines, human-computer interaction (HCI) and management information systems (MIS). More specifically, research was conducted to evaluate the possibility of overlap between the two divergent fields. The Technology Acceptance Model (TAM) from MIS research was examined in light of the HCI constructs of efficiency, effectiveness, and satisfaction. Of interest was the impact of efficiency, effectiveness, and satisfaction on the formulation of user perceptions of ease of use.

The empirical data suggests that satisfaction plays a major role in the formulation of user perceptions ($p<0.01$), while the role of efficiency and effectiveness are minimal.

14. Subject Terms

Technology Acceptance, Ease of Use, Usabilty, Effectiveness, Efficiency, Satisfaction

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